

What is claimed is:

- 1 1. An apparatus for measuring particle motion, the apparatus comprising:
2 a plurality of beams of radiation, each of said plurality of beams modulated at a
3 respective, pre-determined frequency and a respective, pre-determined phase, said plurality
4 of beams of radiation directed at at least one particle;
5 a detector positioned to receive radiation scattered from each of said plurality of
6 beams by said at least one particle;
7 a processor in electrical communication with said detector, said processor cross-
8 correlating radiation scattered from each of said plurality of beams by said at least one
9 particle.
- 1 2. The apparatus of claim 1, wherein said radiation scattered comprises a random
2 component and a modulated frequency, the random component having at least one of its
3 characteristic frequencies lower than the modulated frequency of any of said plurality of
4 beams.
- 1 3. The apparatus of claim 1, further comprising a phase sensitive detection circuit in
2 electrical communication with said detector.
- 1 4. The apparatus of claim 1, wherein said plurality of beams of radiation comprises
2 planes of radiation.
- 1 5. The apparatus of claim 4, wherein separation of at least two of said plurality of beams
2 of radiation is determined by a correlation distance of said at least one particle.
- 1 6. The apparatus of claim 5, wherein said separation is between about 1 mm and about 1
2 cm.
- 1 7. The apparatus of claim 1, wherein at least one of said plurality of beams of radiation
2 is produced by a laser diode.

1 8. The apparatus of claim 7, wherein said laser diode comprises a wavelength of about
2 650 nm.

1 9. The apparatus of claim 1, wherein at least one of said plurality of beams of radiation
2 is square wave modulated.

1 10. The apparatus of claim 9, wherein at least one of said plurality of beams of radiation
2 is modulated at a frequency between about 20 kHz and 100 MHz.

1 11. The apparatus of claim 1, wherein at least one of said plurality of beams of radiation
2 is modulated at a frequency different from another of said plurality of beams.

1 12. The apparatus of claim 1, wherein said plurality of beams of radiation comprises two
2 orthogonal beam pairs.

1 13. The apparatus of claim 1, wherein said plurality of beams of radiation comprises three
2 orthogonal beam pairs.

1 14. The apparatus of claim 1, wherein said plurality of beams of radiation comprises a
2 plurality of non-orthogonal beam pairs.

1 15. The apparatus of claim 1, wherein said processor calculates particle velocity.

1 16. The apparatus of claim 1, wherein said processor calculates particle size.

1 17. The apparatus of claim 1, wherein the pre-determined frequency of a first beam of the
2 plurality of beams of radiation is substantially similar to the pre-determined frequency of a
3 second beam of the plurality of beams of radiation, and the pre-determined phase of the first
4 beam of the plurality of beams of radiation is substantially orthogonal to the pre-determined
5 phase of the second beam of the plurality of beams of radiation.

1 18. A method of measuring motion of a particle, the method comprising:
2 directing radiation from a plurality of beams at at least one particle, each of said
3 plurality of beams modulated at a respective, pre-determined frequency and a respective, pre-
4 determined phase;
5 detecting radiation scattered from each of said plurality of beams by said at least one
6 particle; and
7 cross-correlating said radiation scattered from each of said plurality of beams by said
8 at least one particle to measure the motion of said at least one particle.

1 19. The method of claim 18, wherein said radiation scattered comprises a random
2 component and a modulated frequency, the random component having at least one of its
3 characteristic frequencies lower than the modulated frequency of any of said plurality of
4 beams.

1 20. The method of claim 18, wherein said plurality of beams comprises planes of
2 radiation.

1 21. The method of claim 18, wherein separation of said at least two of said plurality of
2 beams is determined by a correlation distance of said at least one particle.

1 22. The method of claim 21, wherein said separation is between about 1 mm and about 1
2 cm.

1 23. The method of claim 18 further comprising modulating at least one of said plurality
2 of beams with a square wave.

1 24. The method of claim 23, further comprising modulating at least one of said plurality
2 of beams at a frequency between about 20 kHz and 100 MHz.

1 25. The method of claim 18, further comprising modulating at least one of the plurality of
2 beams at a frequency different from another of said plurality of beams.

1 26. The method of claim 18, wherein said plurality of beams comprises two orthogonal
2 beam pairs.

1 27. The method of claim 18, wherein said plurality of beams comprises three orthogonal
2 beam pairs.

1 28. The method of claim 18, wherein said plurality of beams comprises a plurality of
2 non-orthogonal beam pairs.

1 29. The method of claim 18, further comprising calculating particle velocity.

1 30. The method of claim 18, further comprising calculating particle size.

1 31. The method of claim 18, wherein the pre-determined frequency of a first beam of the
2 plurality of beams is substantially similar to the pre-determined frequency of a second beam
3 of the plurality of beams, and the pre-determined phase of the first beam of the plurality of
4 beams is substantially orthogonal to the pre-determined phase of the second beam of the
5 plurality of beams.

1 32. The method of claim 18, wherein the at least one particle is contained in a fluid.

1 33. The method of claim 32, wherein particle velocity corresponds to velocity of said
2 fluid.

1 34. An apparatus for measuring particle motion, the apparatus comprising:
2 means for directing radiation from a plurality of beams at at least one particle, each of
3 said plurality of beams modulated at a respective, pre-determined frequency and a respective,
4 pre-determined phase;
5 means for detecting radiation scattered from each of said plurality of beams by said at
6 least one particle; and

7 means for cross-correlating said radiation scattered from each of said plurality of
8 beams by said at least one particle to measure the motion of said at least one particle.

1 35 The apparatus of claim 34, wherein said radiation scattered comprises a random
2 component and a modulated frequency, the random component having at least one of its
3 characteristic frequencies lower than the modulated frequency of any of said plurality of
4 beams.

1 36. The apparatus of claim 34, wherein the at least one particle is contained in a fluid.